The Accumulation of Helium in Geological Time.—IV.*

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There is very special interest in searching among the Archæan rocks for minerals showing a high ratio of helium to radioactive matter. It is here that we might expect to find the strongest evidence that this method of enquiry can afford for the antiquity of the globe: nor is the expectation falsified by results.

Archæan rocks, from their crystalline nature, afford much more choice of minerals than do the fossiliferous formations. A conspicuous example of large helium ratio is already known in thorianite. Several other examples have, however, been brought to light by the present experiments, which show a higher ratio than this substance. I select the most striking of these by way of illustration.

The minerals in question come from crystalline rocks in various parts of the world. Only those from Norway and from North America are, as far as I know, proved by definite evidence to underlie the older fossiliferous formations. In the other cases it is only on general grounds that the same order of antiquity can be presumed.

In striking contrast to the sphenes from Archæan rocks is a sample from the recent volcanic rocks of the Laacher See (No. 1 on list). These are the only sphenes I have examined. The extreme antiquity indicated by the measurements is about 700 million years for Archæan rocks. It must not be forgotten that this is a minimum.

There is one point which requires special discussion. In a paper published in the 'Proceedings,'† I showed that the mineral beryl contained a quantity of helium out of all proportion to its radioactive content. The alternative explanations are—

(1) Beryl might be supposed much older than any other mineral examined. Although the rocks in which beryl occurs are not in general easily dated geologically, this supposition has little plausibility, the more so that many beryls from different localities have shown the same feature.

(2) A much more plausible explanation, suggested to me by Dr. Boltwood,

* For previous papers, see 'Roy. Soc. Proc.,' A, vol. 81, p. 272; vol. 83, p. 96; vol. 83, p. 298.

† *Ibid.*, A, vol. 80, p. 572.

Table of Results.*

No.	Mineral and locality.	Geological age.	Per gramme.				Helium ratio.
			Helium, c.c. × 10^{-4}.	U_3O_8, grammes × 10^{-4}.	ThO_2, grammes × 10^{-4}.	Total equivalent, U_3O_8.	
1	Sphene. Laacher See	Tertiary.....	<0·06	0·497	17·2	3·99	<0·015
2	„ Cold Spring, New York ...	Archaean	101	1·87	4·23	2·73	37·0
3	„ Lewis Co., New York	„	166	2·71	3·68	3·46	47·8
4	„ Renfrew Co., Ontario	„	94·8	4·30	1·98	4·70	20·2
5	„ „ „	„	176	1·72	4·82	2·70	65·0
6	„ Twederstrand, Norway ...	„	33·6	0·772	4·73	1·73	19·4
7	„ „ „ ...	„	45·4	0·921	0·920	1·11	40·8
8	„ Arendal, Norway	„	123	2·46	4·34	3·34	36·8
9	Thorianite. Ceylon	„	93,000	2450	6544	3780	24·6
10	„ „	„	78,000	1310	7265	2785	27·9
11	Fluor. Ivitgut, Greenland	„	193	0·030	18·2	3·72	51·8
12	Beryl. Acworth, New Hampshire...	Palaeozoic.....	128	0·014†	0	0·014	9140

* The notation of this table is as in previous papers.

† In former measurements on this mineral the radium was much over-estimated, presumably owing to accidental contamination. Thus the remarkable character of the result was much understated.

is as follows:—Beryl is a substance of extremely peculiar composition. Its crystallisation from the rock magma, which can only contain beryllia at a great dilution, is a process hard to understand, and one about which it would be rash to dogmatise. It is, however, permissible to imagine that one of the longer lived radioactive products, say radium, ionium, or radio-thorium, which we know also to be present in the magma, might also be separated by this peculiar crystallisation, in a relatively concentrated form. In a few thousand years such a constituent of the beryl would have lost its activity, and nothing but the helium to which it had given birth would remain recognisable.

If this view is accepted, the question will no doubt be asked, What evidence is there that a similar process has not gone on in the other cases, such as zircon, sphene, or thorianite, relied upon to give a minimum estimate of the age of the rocks in which they occur?

It can only be replied—

(1) Such minerals show a close connection between the helium ratio and the geological age.* As regards sphene, the above table shows the results obtained from a sphene of late tertiary date, which shows a helium ratio quite insignificant compared with *any* of the numerous Archæan specimens examined.

(2) The helium content in cases other than beryl is in close relation to the amount of radioactive matter now present, the ratio being, for instance, of the same order for thorianite as for Archæan sphene and zircon; while the former is a thousand times more active than the latter.

* For evidence of this as regards zircons, see 'Roy. Soc. Proc.,' A, vol. 83, p. 298.